CII Electrical Power System Guidelines

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Interface Assumptions

- The Host Spacecraft will have a primary mission different than that of the Instrument. As a hosted payload, the Instrument’s most important directive is to not interfere or cause damage to the Host Spacecraft or any of its payloads, sacrificing its own safety for that of the rest of the observatory/bus.
- [GEO] Nominal Orbit: The Host Spacecraft will operate in GEO with an altitude of approximately 35786 kilometers and eccentricity and inclination of approximately zero.
- [LEO] Nominal Orbit: The Host Spacecraft will operate in LEO with an altitude between 350 and 2000 kilometers with eccentricity less than 1 and inclination between zero and 180°, inclusive.
- Responsibility for Integration: The Host Spacecraft Manufacturer will integrate the Instrument onto the Host Spacecraft with support from the Instrument Developer.

Interface Assumptions

The CII electrical power guidelines assume the following regarding the Host Spacecraft:

- During the matching process, the Host Spacecraft Manufacturer/Systems Integrator and the Instrument Developer will negotiate detailed parameters of the electrical power interface. The Electrical Power Interface Control Document (EICD) will record those parameters and decisions.
- The Host Spacecraft will supply electrical power to the Instrument Electrical Power System (EPS) with voltage range constraints inclusive of ripple, normal transients and power distribution losses due to switching, fusing, harness and connectors as described in the associated guideline(s).
- The Host Spacecraft will provide connections to the Instrument electrical power buses as well as a dedicated bus to power the Instrument’s survival heaters as described in the associated guideline(s). Each bus will have a primary and redundant circuit. For the purpose of illustration, this document labels these buses as Power Bus #1, Power Bus #2, and Survival Heater Power Bus. This document also labels the primary and redundant circuits as A and B, respectively. Figure 5-1 shows a pictorial representation of this architecture.

Interface Assumptions

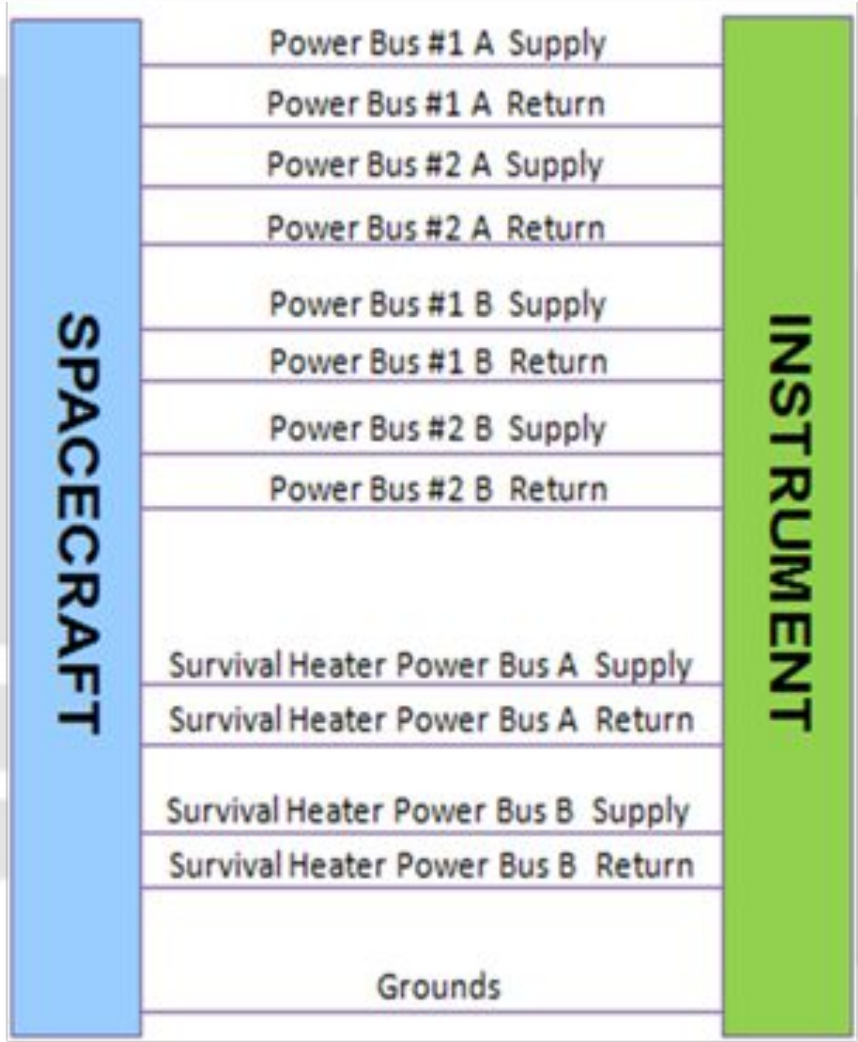

Figure 5-1: Spacecraft-Instrument Electrical Interface (Depicted with the optional Instrument side redundant Power Bus B interface)

Interface Assumptions

- The Host Spacecraft will energize the Survival Heater Power Bus at 30% of the OAP [LEO]/AP [GEO] in accordance with the mission timeline documented in the EICD.
- The Host Spacecraft will supply a definition of the maximum source impedance by frequency band. Table 5-1 provides an example of this definition.

Table 5-1: Example of Power Source Impedance Function

Frequency	Maximum Source Impedance (Ω)
1 Hz to 1 kHz	0.2
1 kHz to 20 kHz	1.0
20 kHz to 100 kHz	2.0
100 kHz to 10 MHz	20.0

- The Host Spacecraft Manufacturer will furnish all Spacecraft and Spacecraft-to-Instrument harnessing.
- The Host Spacecraft will deliver Instrument power via twisted conductor (pair, quad, etc.) cables with both power and return leads enclosed by an electrical overshield.
- The Host Spacecraft will protect its own electrical power system by installing overcurrent protection devices on its side of the interface.

Interface Assumptions

- The Host Spacecraft will utilize the same type of overcurrent protection device, such as latching current limiters or fuses, for all connections to the Instrument.
- In the event that the Host Spacecraft battery state-of-charge falls below 50%, the Host Spacecraft will power off the Instrument after placing the Instrument in SAFE mode. Instrument operations will not resume until the ground operators have determined it is safe to return to OPERATION mode.
- The Host Spacecraft will deliver a maximum transient current on any Power Feed bus of 100 percent (that is, two times the steady state current) of the maximum steady-state current for no longer than 50 ms.
- The Host Spacecraft will provide access to its Electrical Power System using the interface defined in Section 5.1.

The following definitions have been applied to the EPS accommodations:

- Average Power Consumption: the total power consumed averaged over any 180-minute period.
- Peak Power Consumption: the maximum power consumed averaged over any 10 ms period.

EPS L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.4	EPS Interface	The Instrument should electrically ground to a single point on the Host Spacecraft.	The Instrument Electrical Power System (EPS) should ground in a way that reduces the potential to introduce stray currents or ground loop currents into the Instrument, Host Spacecraft, or other payloads.

EPS L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.5	EPS Accommodation	[LEO] The Instrument EPS should draw less than or equal to 100W, averaged over the orbit, from the Host Spacecraft.	CII analysis of the NICM Database shows 100 W to be the upper bound for instrument likely to find rides as LEO hosted payloads.

EPS L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.5	EPS Accommodation	[LEO] The Instrument EPS should accept an unregulated input voltage of 28 ± 6 VDC.	The EPS architecture is consistent across LEO spacecraft bus manufacturers with the available nominal voltage being 28 Volts Direct Current (VDC) in an unregulated (sun regulated) configuration. If a prospective Host Spacecraft EPS architecture is not configured in accordance with the noted guidance, then the Instrument Developer may consider the following courses of action: perform a more restrictive Instrument / Host Spacecraft pairing exercise, procure any modifications necessary to the Host Spacecraft so that it will supply the required voltage, or incorporate a space flight-qualified voltage converter into the Instrument.

EPS L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.5	EPS Accommodation	[GEO] The Instrument should draw less than or equal to 300W of electrical power from the Host Spacecraft.	The Host Spacecraft bus EPS available power varies significantly both by manufacturer and by spacecraft bus configuration. 300 Watts represents a power level that all of the primary manufacturers’ buses can accommodate, and requiring a power level less than this increases the likelihood of funding a suitable Host Spacecraft. If the Instrument requires more than 300W of electrical power, then the Instrument Developer could choose either to perform a more restrictive Instrument/Host Spacecraft pairing exercise or procure an upgraded (and likely more expensive) version of a Host Spacecraft that meets those requirements.

EPS L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.5	EPS Accommodation	[GEO] The Instrument EPS should accept a regulated input voltage of 28 ± 3 VDC.	Host Spacecraft bus voltages vary by manufacturer, who design electrical systems with the following nominal voltages: 28, 36, 50, 70, and 100 VDC. To maximize both voltage conversion efficiency and available hosting opportunities, the Instrument should accept the lowest nominal voltage provided, which is 28 VDC. Note: This guideline may be superseded by Instruments that have payload-specific voltage or power requirements or by “resistance only” power circuits.

EPS L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.5	EPS Accommodation	[GEO] The Instrument payload primary heater circuit(s), survival heater circuit(s) and other "resistance only" power circuits that are separable subsystems of the Instrument payload EPS should accommodate the Host Spacecraft bus nominal regulated voltage and voltage tolerance.	Host Spacecraft bus voltages vary by manufacturer, who design electrical systems with the following nominal voltages: 28, 36, 50, 70, and 100 VDC. To minimize the amount of power required to be converted to an input voltage of 28 ± 3 VDC and to maximize the available hosting opportunities, an instrument should design the "resistance only" power loads to accept the spacecraft bus nominal voltage.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.1	EPS Interface Power Bus Interface	The EPS should provide nominal power to each Instrument component via one or both of the Power Buses.	The Power Buses supply the electrical power for the Instrument to conduct normal operations. Depending on the load, a component may connect to one or both of the power buses. Note: The utilization of the redundant power circuits (Power Circuits B) by the Instrument is optional based upon instrument mission classification, reliability, and redundancy requirements.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.2	EPS Interface Survival Heater Bus Interface	The EPS should provide power to the survival heaters via the Survival Heater Power Bus.	The Survival Heaters, which are a member of the Thermal subsystem, require power to heat certain instrument components during off-nominal scenarios when the Power Buses are not fully energized. See Best Practices sections 9.2.3 and 9.4.2 for more discussion about survival heaters.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.3	EPS Interface Grounding	The Instrument grounding architecture should comply with NASA-HDBK-4001.	The Instrument grounding architecture must be established at the earliest point in the design process. The implementation of the subject level 1 guidance in conjunction with the consistent and proven design principles described in the ascribed reference will support a successful instrument development and integration to a Host Spacecraft and mission.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.4	EPS Interface Grounding Documentation	The EICD will document how the Instrument will ground to the Host Spacecraft.	It is necessary to define and document the Instrument to Host Spacecraft grounding interface architecture.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.5	EPS Interface Bonding	The Instrument bonding should comply with NASA-STD-4003.	The instrument bonding practices must be defined to support the instrument design and development process. The implementation of the subject reference will provide consistent and proven design principles and support a successful instrument development, integration to a Host Spacecraft and mission.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.6	EPS Interface Mitigation of In-Space Charging Effects	The Instrument should comply with NASA-HDBK-4002 to mitigate in-space charging effects.	The application of the defined reference to the Instrument grounding architecture and bonding practices will address issues and concerns with the in-flight buildup of charge on internal spacecraft components and external surfaces related to space plasmas and high-energy electrons and the consequences of that charge buildup.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.7	EPS Interface Instrument Harnessing	The Instrument Developer should furnish all Instrument harnessing.	The Instrument Developer is responsible for all harnesses that are constrained by the boundaries of the Instrument as a single and unique system. This refers only to those harnesses that are interconnections between components (internal and external) of the Instrument system and excludes any harnesses interfacing with the Host Spacecraft or components that are not part of the Instrument system.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.2.8	EPS Interface Harness Documentation	The EICD will document all harnesses, harness construction, pin-to-pin wiring, cable type, connectors, ground straps, and associated service loops.	The EICD documents agreements made between the Host Spacecraft Manufacturer and Instrument Developer regarding harness hardware and construction.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.3.2	EPS Accommodation Instrument Power Harness	Instrument power harnesses should be appropriately sized to support the peak Instrument power level and both Host Spacecraft and Instrument overcurrent protection devices.	Sizing all components of the Instrument power harness, such as the wires, connectors, sockets, and pins to the peak power level required by the Instrument and Host Spacecraft prevents damage to the power harnessing.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.3.3	EPS Accommodation Allocation of Instrument Power	The EPS should draw no more power from the Host Spacecraft in each Instrument mode as defined in Table 5-2.	The Level 1 guideline defines power allocation for the OPERATION mode. The assumption that the instrument requires 100% of the power required in the OPERATION mode defines the power allocation for the ACTIVATION mode. The assumption that the instrument requires 50% of the power required in the OPERATION mode defines the power allocation for the SAFE mode. The assumption that the instrument only requires survival heater power defines the power allocation for the SURVIVAL mode.

Table 5-2: Instrument Power Allocation

Mode	LEO		GEO
	Peak (W)	Average (W)	Average (W)
OFF/ SURVIVAL	0/60	0/30	0/90
ACTIVATION	200	100	300
SAFE	100	50	150
OPERATION	200	100	300

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.3.4	EPS Accommodation Unannounced Removal of Power	The Instrument should function according to its operational specifications when nominal power is restored following an unannounced removal of power.	In the event of a Host Spacecraft electrical malfunction, the instrument would likely be one of the first electrical loads to be shed either in a controlled or uncontrolled manner.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.3.5	EPS Accommodation Reversal of Power	The Instrument should function according to its operational specifications when proper polarity is restored following a reversal of power (positive) and ground (negative).	This defines the ability of an instrument to survive a power reversal anomaly which should be uncommon during assembly, integration, and test (AI&T) but does periodically occur.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.3.6	EPS Accommodation Power-Up and Power-Down	The Instrument should function according to its operational specifications when the Host Spacecraft changes the voltage across the Operational Bus from +28 to 0 VDC or from 0 to +28 VDC as a step function.	A necessary practice to preclude instrument damage/degradation.

EPS L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
5.3.7	EPS Accommodation Abnormal Operation Steady-State Voltage Limits	The Instrument should function according to its operational specifications when the Host Spacecraft restores nominal power following exposure to steady-state voltages from 0 to 50 VDC.	Defines a verifiable (testable) limit for off-nominal input voltage testing of an instrument.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.2.1	Electrical Interface Definitions *Power Bus Current Rate of Change*	For power bus loads with current change greater than 2 A, the rate of change of current should not exceed 500 mA/µs.	This describes the maximum nominal rate of change for instrument electrical current to bound nominal and anomalous behavior.
9.2.2.2	Electrical Interface Definitions *Power Bus Isolation*	All Instrument power buses (both operational and survival) should be electrically isolated from each other and from chassis.	Circuit protection and independence.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.2.3	Electrical Interface Definitions *Power Bus Returns*	All Instrument power buses (both operational and survival heater) should have independent power returns.	Circuit protection and independence.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.3.1	Survival Heaters *Survival Heater Power Bus Circuit Failure*	The Instrument survival heater circuit should prevent a stuck on condition of the survival heaters due to internal failures.	A stuck-on survival heater could lead to excessive power draw and/or over temperature events in the Instrument or Host Spacecraft. This is normally accomplished by using series-redundant thermostats in each survival heater circuit.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.3.2	Survival Heaters *Survival Heater Power Bus Heater Type*	The Instrument should use only resistive heaters (and associated thermal control devices) to maintain the Instrument at survival temperature when the main power bus is disconnected from the Instrument.	This preserves the survival heater power bus for exclusive use of resistive survival heaters, whose function is to maintain the Instrument at a minimum turn-on temperature when the Instrument Power Buses are not energized.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.3.3	Survival Heaters *Survival Heater Power Bus Design*	The system design should be such that having both primary and redundant survival heater circuits enabled does not violate any thermal or power requirement.	This precludes excessive power draw and/or over-temperature events in the Instrument or Host Spacecraft. This is normally accomplished via the application of thermostats with different set points in each redundant survival heater circuit.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.1	Voltage and Current Transients *Low Voltage Detection*	A voltage excursion that causes the spacecraft Primary Power Bus to drop below 22 VDC in excess of four seconds constitutes an under-voltage condition. In the event of an under-voltage condition, the spacecraft will shed various loads without delay, including the Instrument. A ground command should be required to re-power the load.	Bounds nominal and anomalous design conditions. Describes “typical” spacecraft CONOPS to the noted anomaly for application to design practice.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.2	Voltage and Current Transients *Bus Undervoltage and Overvoltage Transients*	Derating factors should take into account the stresses that components are subjected to during periods of undervoltage or overvoltage, including conditions which arise during ground testing, while the bus voltage is slowly brought up to its nominal value.	Describes a “standard” design practice.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.3	Voltage and Current Transients *Bus Undervoltage and Overvoltage Transients*	The Instrument should not generate a spurious response that can cause equipment damage or otherwise be detrimental to the spacecraft operation during bus voltage variation, either up or down, at ramp rates below the limits specified in the sections below, and over the full range from zero to maximum bus voltage.	The Instrument needs to be able to tolerate appropriate electrical transients without affecting the Host Spacecraft.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.4	Voltage and Current Transients *Abnormal Transients Undervoltage*	An abnormal undervoltage transient event is defined as a transient decrease in voltage on the Power Bus to no less than +10 VDC, maintaining the decreased voltage for no more than 10 ms, and returning to its previous voltage in less than 200 ms.	A necessary definition of an Abnormal Transient Undervoltage

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.7	Voltage and Current Transients *Abnormal Transients Overvoltage*	An overvoltage transient event is defined as an increase in voltage on the Power Bus to no greater than +40 VDC, maintaining the increased voltage for no more than 10 ms, and returning to its previous voltage in less than 200 ms.	A necessary definition of an Abnormal Transient Overvoltage

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.8	Voltage and Current Transients *Instrument Initial In-rush Current*	After application of +28 VDC power at *t0, the initial inrush (charging) current due to* distributed capacitance, EMI filters, etc., should be completed in 10 µs with its peak no greater than 10 A.	Bounds nominal and anomalous behavior.
9.2.4.9	Voltage and Current Transients *Instrument Initial In-rush Current Rate of Change*	The rate of change of inrush current after the initial application of +28V power should not exceed 20 mA/µs.	Bounds nominal and anomalous behavior.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.5	Voltage and Current Transients *Abnormal Transients Tolerance*	The Instrument should ensure that overstress does not occur to the unit during an undervoltage event.	The Instrument needs to tolerate the abnormal voltage transients, which can be expected to occur throughout its mission lifetime.
9.2.4.6	Voltage and Current Transients *Abnormal Transients Recovery*	Units which shut-off during an undervoltage should return to a nominal power-up state at the end of the transient.	The Instrument needs to tolerate the abnormal voltage transients, which can be expected to occur throughout its mission lifetime.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.10	Voltage and Current Transients *Instrument In-rush Current after 10 μs*	After 10μs, the transient current peak should not exceed three times the maximum steady state current.	Bounds nominal and anomalous behavior.
9.2.4.11	Voltage and Current Transients *Instrument Steady State Operation*	Steady state operation should be attained within 50 ms from turn-on or transition to OPERATION mode, except for motors.	Bounds nominal and anomalous behavior with a maximum transient duration of 50 ms.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.12	Voltage and Current Transients *Instrument Turn-off Peak Voltage Transients*	The peak voltage of transients generated on the Instrument side of the power relay caused by inductive effects of the load should fall within the -2 VDC to +40 VDC range.	Bounds nominal behavior.
9.2.4.13	Voltage and Current Transients *Instrument Turn-off Transient Suppression*	The Instruments should use suppression devices, such as diodes, across all filter inductors, relay coils, or other energy sources that could induce transients on the power lines during turn-off.	Describes design "standard practice."

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.14	Voltage and Current Transients *Reflected Ripple Current – Mode Changes*	The load current ripple due to rpm mode changes should not exceed 2 times the steady state current during the period of the motor spin-up or spin-down.	Bounds nominal behavior.
9.2.4.15	Voltage and Current Transients *Instrument Operational Transients Current Limit*	Operational transients that occur after initial turn-on should not exceed 125% of the peak operational current drawn during normal operation.	Bounds nominal behavior.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.4.16	Voltage and Current Transients *Instrument Reflected Ripple Current*	The peak-to-peak load current ripple generated by the Instrument should not exceed 25% of the average current on any Power Feed bus.	Bounds nominal behavior.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.5.1	Overcurrent Protection *Overcurrent Protection Definition*	The analysis defining the overcurrent protection device specification(s) should consider turn-on, operational, and turn-off transients.	Describes conditions necessary for inclusion in the “standard” design practice.
9.2.5.2	Overcurrent Protection *Overcurrent Protection – Harness Compatibility*	Harness wire sizes should be consistent with overcurrent protection device sizes and de-rating factors.	Describes a “standard” design practice.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.5.3	Overcurrent Protection *Overcurrent Protection Device Size Documentation*	The EICD will document the type, size, and characteristics of the overcurrent protection devices.	Describes "standard practice" EICD elements.
9.2.5.4	Overcurrent Protection *Instrument Overcurrent Protection*	All Instrument overcurrent protection devices should be accessible at the Spacecraft integration level without any disassembly of the Instrument.	Accessible overcurrent protection devices allow Systems Integrator technicians to more easily restore power to the Instrument in the event of an externally-induced overcurrent.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.5.5	Overcurrent Protection *Instrument Fault Propagation Protection*	The Instrument and spacecraft should not propagate a single fault occurring on either the "A" or "B" power interface circuit, on either side of the interface, to the redundant interface or Instrument.	This preserves redundancy by keeping faulty power circuits from impacting alternate power sources.
9.2.5.6	Overcurrent Protection *Testing of Instrument High-Voltage Power Supplies in Ambient Conditions*	Instrument high-voltage power supplies should operate nominally in ambient atmospheric conditions.	This allows simplified verification of the high-voltage power supplies.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.5.7	Overcurrent Protection *Instrument High-Voltage Current Limiting*	The output of each Instrument's high-voltage supply should be current limited to prevent the supply's discharge from damaging the Spacecraft and other Instruments.	This prevents the power supply's discharge from damaging the Host Spacecraft or other payloads.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.1	Connectors *Instrument Electrical Power System Connector and Harnessing*	The Instrument electrical power system harnessing and connectors should conform to GSFC-733-HARN, IPC J-STD-001ES and NASA-STD-8739.4.	Describes the appropriate design practices for all Instrument electrical power connections and harnessing.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.2	Connectors *Connector Savers*	Throughout all development, integration, and test phases, connector savers should be used to preserve the mating life of component flight connectors.	This practice serves to preserve the number of mate/de-mate cycles any particular flight connector experiences. Mate/de-mate cycles are a connector life-limiting operation. This practice also protects flight connects form damage during required connector mate/de-mate operations.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.3	Connectors *Connector Separation*	The Instrument should physically separate the electric interfaces for each of the following functions using distinct connectors: 1) +28 VDC bus power and return 2) Telemetry and command signals with returns 3) Deployment actuation power and return (where applicable)	A "standard" design practice to preclude mismating and to simplify test and anomaly resolution.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.4	Connectors *Command and Telemetry Returns*	Telemetry return and relay driver return pins should reside on the same connector(s) as the command and telemetry signals.	A "standard" design practice to simplify testing and anomaly resolution.
9.2.6.5	Connectors *Connector Usage and Pin Assignments*	Harness side power connectors and all box/ bracket-mounted connectors supplying power to other components should have female contacts.	Unexposed power supply connector contacts preclude arcing, mismating, and contact shorting.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.6	Connectors *Connector Function Separation*	Incompatible functions should be physically separated.	A "standard" design practice to ensure connector conductor self-compatibility that precludes arcing and inductive current generation.
9.2.6.7	Connectors *Connector Derating*	Instrument and Spacecraft should derate electrical connectors using *Electronic Parts, Materials, and Processes for Space and Launch Vehicles (MIL-HDBK-1547A) as a guide.*	A "standard" design practice.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.8	Connectors *Connector Access*	At least 50 mm of clearance should exist around the outside of mated connectors.	Ensures the ability to perform proper connector mate/de-mate operations.
9.2.6.9	Connectors *Connector Engagement*	Connectors should be mounted to ensure straight and free engagement of the contacts.	This precludes mismating connectors.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.10	Connectors *Power Connector Type*	The Instrument power connectors should be space-flight qualified General Specification for Connectors, Electric, Rectangular, Nonenvironmental, Miniature, Polarized Shell, Rack and Panel (MIL-DTL-24308), Class M, Subminiature Rectangular connectors with standard density size 20 crimp contacts and conform to Connectors, Electrical, Polarized Shell, Rack and Panel, for Space Use (GSFC S-311-P-4/09).	Connector sizes and types selected based upon familiarity, availability, and space flight qualification.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.11	Connectors *Power Connector Size and Conductor Gauge*	The Instrument power connectors should be 20 AWG, 9 conductor (shell size 1) , 15 conductor (shell size 2) or 25 conductor (shell size 3) connectors.	Application of stated design practices to the CII instrument power bus connectors.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.12	Connectors *Power Connector Pin Out*	The Instrument power connectors should utilize the supply and return pin outs defined in Table 9-1 and identified in Figure 9-1 thru Figure 9-3.	Application of stated design practices to the CII instrument power bus connectors.

Table 9-1: Instrument Power Connector Pin Out Definition

Power Bus	Circuit	Supply Conductor Position	Return Conductor Position
#1	A & B	14,15,16,23,24,25	1,2,3,11,12,13
#2	A & B	9,10,11,13,14,15	1,2,3,6,7,8
Survival Heater	A & B	6,7,8,9	1,2,4,5

EPS Best Practices

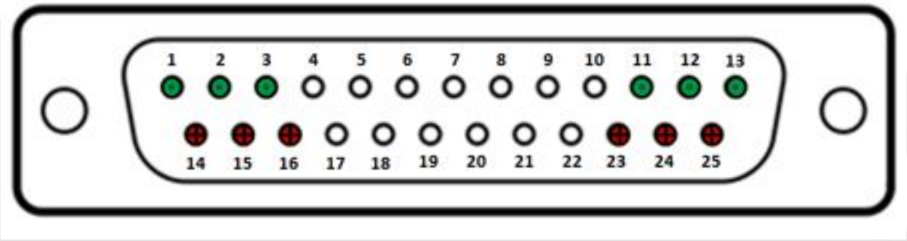

Figure 9-1: Instrument Side Power Bus #1 Circuit A & Circuit B

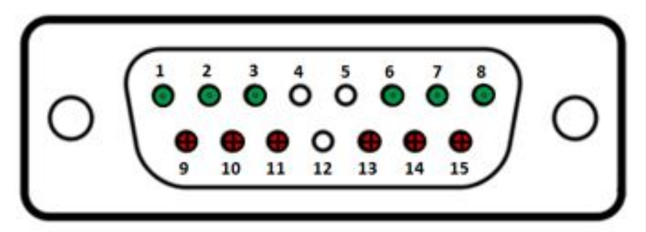

Figure 9-2: Instrument Side Power Bus #2 Circuit A & Circuit B

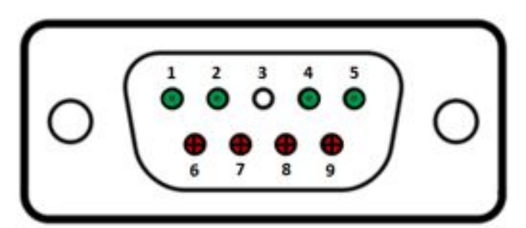

Figure 9-3: Instrument Side Survival Heater Power Bus Circuit A & Circuit B

Note that connectors are depicted with the instrument side of the connector (pins) shown while the spacecraft side of the connector (sockets) is the mirror image.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.13	Connectors *SpaceWire Connectors and Harnessing*	The Instrument SpaceWire harnessing and connectors should conform to ECSS-E-ST-50-12C.	Describes the appropriate design practice for all SpaceWire connections and harnessing.
9.2.6.14	Connectors *Power Connector Provision*	The Instrument Provider should furnish all instrument power mating connectors (Socket Side) to the Spacecraft Manufacturer for interface harness fabrication.	Describes the appropriate design practice for all SpaceWire connectors.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.15	Connectors *Power Connector Conductor Size and Type*	The Instrument should have size 20 socket crimp contacts on the Instrument side power connectors and size 20 pin crimp contacts on the Spacecraft side power connectors.	Application of the conductor size and type selected for the CII instrument power bus connectors to the corresponding instrument power connectors.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.16	Connectors *Power Connector Keying*	The instrument power connectors should be keyed as defined in Figure 9-4.	Application of stated design practices to the CII instrument power bus connectors.

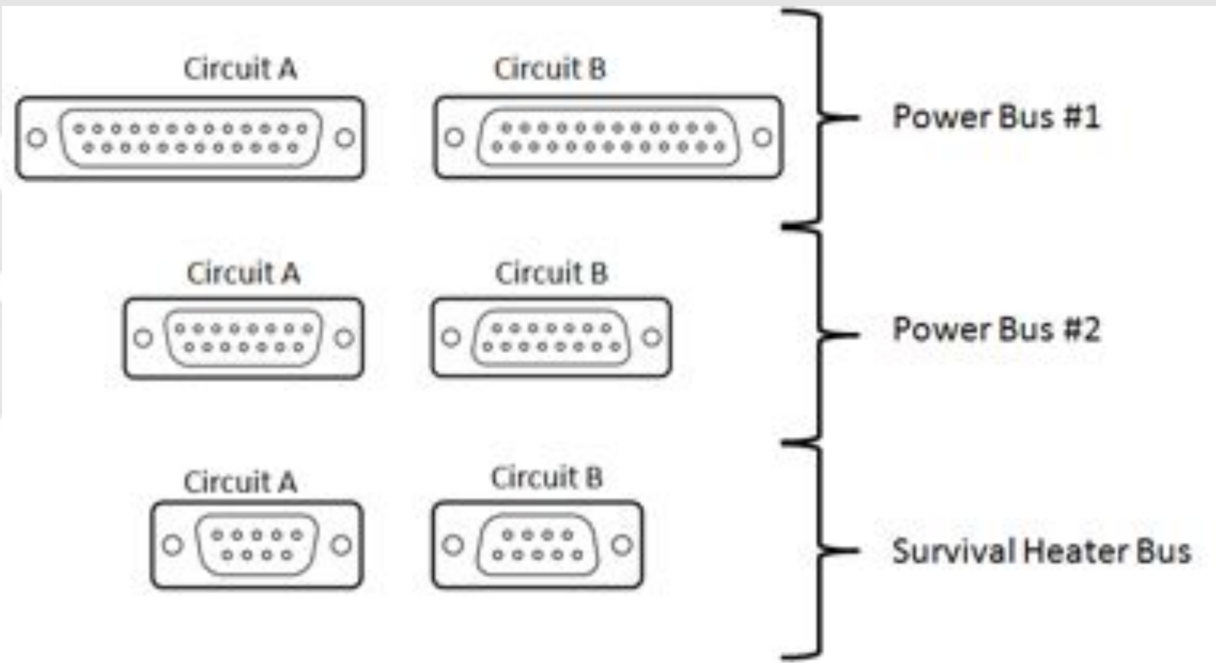

Figure 9-4: Power Connector Keying

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.17	Connectors *Connector Type Selection*	All connectors to be used by the Instrument should be selected from the Goddard Spaceflight Center (GSFC) Preferred Parts List (PPL).	Utilizing the GSPC PPL simplifies connector selection, since all of its hardware is spaceflight qualified.
9.2.6.18	Connectors *Flight Plug Installation*	Flight plugs requiring installation prior to launch should be capable of being installed at the Spacecraft level.	Ensures necessary access.

EPS Best Practices

ID	Function	Guidelines	Rationale/Comment
9.2.6.19	Connectors *Test Connector Location and Types*	Test connector and coupler ports should be accessible without disassembly throughout integration of the Instrument and Host Spacecraft.	This reduces the complexity and duration of integrated testing and simplifies preflight anomaly resolution.

Summary of EPS Guidelines

- 2.0 LEVEL 1 DESIGN GUIDELINES
  - 2.2.4 Electrical Power System Interface
  - 2.2.5 Electrical Power System Accommodation
- 5.0 ELECTRICAL POWER SYSTEM LEVEL 2 GUIDELINES
  - 5.2 EPS Interface
    - 5.2.1 Power Bus Interface
    - 5.2.2 Survival Heater Bus Interface
    - 5.2.3 Grounding
    - 5.2.4 Grounding Documentation
    - 5.2.5 Bonding
    - 5.2.6 Mitigation of In-Space Charging Effects
    - 5.2.7 Instrument Harnessing
    - 5.2.8 Harness Documentation
  - 5.3 EPS Accommodation
    - 5.3.2 Instrument Power Harness
    - 5.3.3 Allocation of Instrument Power
    - 5.3.4 Unannounced Removal of Power
    - 5.3.5 Reversal of Power
    - 5.3.6 Power-Up and Power-Down
    - 5.3.7 Abnormal Operation Steady-State Voltage Limits

Summary of EPS Guidelines

- 9.0 REFERENCE MATERIAL / BEST PRACTICES
  - 9.2 Electrical Power Interface Reference Material / Best Practices
    - 9.2.2 Electrical Interface Definitions
      - 9.2.2.1 *Power Bus Current Rate of Change*
      - 9.2.2.2 *Power Bus Isolation*
      - 9.2.2.3 *Power Bus Returns*
    - 9.2.3 Survival Heaters.
      - 9.2.3.1 *Survival Heater Power Bus Circuit Failure*
      - 9.2.3.2 *Survival Heater Power Bus Heater Type*
      - 9.2.3.3 *Survival Heater Power Bus Design*
    - 9.2.4 Voltage and Current Transients
      - 9.2.4.1 *Low Voltage Detection*
      - 9.2.4.2 *Bus Undervoltage and Overvoltage Transients*
      - 9.2.4.3 *Bus Undervoltage and Overvoltage Transients*
      - 9.2.4.4 *Abnormal Transients Undervoltage*
      - 9.2.4.5 *Abnormal Transients Tolerance*
      - 9.2.4.6 *Abnormal Transients Recovery*
      - 9.2.4.7 *Abnormal Transients Overvoltage*
      - 9.2.4.8 *Instrument Initial In-rush Current*

Summary of EPS Guidelines

- 9.0 REFERENCE MATERIAL / BEST PRACTICES
  - 9.2 Electrical Power Interface Reference Material / Best Practices
    - 9.2.4 Voltage and Current Transients (continued)
      - 9.2.4.9 *Instrument Initial In-rush Current Rate of Change*
      - 9.2.4.10 *Instrument In-rush Current after 10 μs*
      - 9.2.4.11 *Instrument Steady State Operation*
      - 9.2.4.12 *Instrument Turn-off Peak Voltage Transients*
      - 9.2.4.13 *Instrument Turn-off Transient Suppression*
      - 9.2.4.14 *Reflected Ripple Current – Mode Changes*
      - 9.2.4.15 *Instrument Operational Transients Current Limit*
      - 9.2.4.16 *Instrument Reflected Ripple Current*
    - 9.2.5 Overcurrent Protection
      - 9.2.5.1 *Overcurrent Protection Definition*
      - 9.2.5.2 *Overcurrent Protection – Harness Compatibility*
      - 9.2.5.3 *Overcurrent Protection Device Size Documentation*
      - 9.2.5.4 *Instrument Overcurrent Protection*
      - 9.2.5.5 *Instrument Fault Propagation Protection*
      - 9.2.5.6 *Testing of Instrument High-Voltage Power Supplies in Ambient Conditions*

Summary of EPS Guidelines

- 9.0 REFERENCE MATERIAL / BEST PRACTICES
  - 9.2 Electrical Power Interface Reference Material / Best Practices
    - 9.2.5 Overcurrent Protection (continued)
      - 9.2.5.7 *Instrument High-Voltage Current Limiting*
    - 9.2.6 Connectors
      - 9.2.6.1 *Instrument Electrical Power System Connector and Harnessing*
      - 9.2.6.2 *Connector Savers*
      - 9.2.6.3 *Connector Separation*
      - 9.2.6.4 *Command and Telemetry Returns*
      - 9.2.6.5 *Connector Usage and Pin Assignments*
      - 9.2.6.6 *Connector Function Separation*
      - 9.2.6.7 *Connector Derating*
      - 9.2.6.8 *Connector Access*
      - 9.2.6.9 *Connector Engagement*
      - 9.2.6.10 *Power Connector Type*
      - 9.2.6.11 *Power Connector Size and Conductor Gauge*
      - 9.2.6.12 *Power Connector Pin Out*
      - 9.2.6.13 *SpaceWire Connectors and Harnessing*

Summary of EPS Guidelines

- 9.0 REFERENCE MATERIAL / BEST PRACTICES
  - 9.2 Electrical Power Interface Reference Material / Best Practices
    - 9.2.6 Connectors
      - 9.2.6.14 *Power Connector Provision*
      - 9.2.6.15 *Power Connector Conductor Size and Type*
      - 9.2.6.16 *Power Connector Keying*
      - 9.2.6.17 *Connector Type Selection*
      - 9.2.6.18 *Flight Plug Installation*
      - 9.2.6.19 *Test Connector Location and Types*